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Bivalvia, Cyrenidae, *Corbicula fluminea* (Müller, 1774): new record, density, and population structure in the Teles Pires River, northern Mato Grosso, Brazil

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Abstract: *Corbicula fluminea* is a very prolific invasive species around the world. In order to document the dispersal of this species in the Midwest Region of Brazil, we sampled 10 sites in the Teles Pires River in September 2006 and September 2012. We standardized the sampling effort by the number of drags, distance and size of the sieve. The average density of *C. fluminea* in 2006 was 6.36 individuals/m² and 26.42 individuals/m² in 2012. *Corbicula fluminea* is adapted to regional environmental characteristics such as climate, temperature and rainfall, and could become a problem in new hydroelectric dams that are setting up on site.

Key words: bioinvasion; Mollusca; Corbiculidae; environmental problems; invasive species; freshwater invasions

Bivalves of the genus *Corbicula fluminea* (Müller, 1774) (Bivalvia: Cyrenidae; formerly Corbiculidae) are among the best known invaders of freshwater ecosystems. Within a few years, *C. fluminea* is capable of establishing itself at new sites (Morton 1979; Vitousek 1990; Sousa et al. 2008b, 2009; Clavero et al. 2012) and reaching high densities (Mansur and Garces 1988).

Corbicula species are native to Asia (Ituarte 1990; Karatayev et al. 2003, 2007) but are currently found worldwide (Mansur et al. 2004, 2012), including Africa (Clavero et al. 2012), Europe (Araújo et al. 1993; Sousa et al. 2007, 2008a, 2009), North America (Sinclair and Isom 1963; Mattice 1977; McMahon 1983) and South America (Ituarte 1985; Mansur and Garces 1988).

The first known introduction of *Corbicula fluminea* anywhere was on the Pacific coast of Canada in the 1920s, possibly introduced by Chinese immigrants as a food (Counts 1981). The North American distribution of *C. fluminea* now extends from coast to coast in the United States. This species is now considered a problem in North America (Sinclair and Isom 1963; Mattice 1977; McMahon 1983). In Europe, *Corbicula fluminea* was first recorded by Mouthon (1981; Sousa et al. 2008b). In Southern Brazil, *C. manilensis* (Philippi, 1844) was discovered between 1965 and 1975 by Mansur and Garces (1988) and Veitenheimer-Mendes (1981). Additionally, Ituarte (1990) discovered *C. fluminea* in the La Plata River, Argentina, in 1985. This species is passively dispersed within watersheds by water currents (Mansur and Garces 1988).

Populations of *C. fluminea* grow and expand rapidly in new environments (Araújo et al. 1993; Karatayev et al. 2003; Sousa et al. 2008b). Human disturbances often favor the establishment of invasive species. For example, the construction of reservoirs for hydropower generation changes environmental conditions and makes vulnerable aquatic ecosystems more susceptible to the establishment of invasive species (Rocha et al. 2005).

Six new hydroelectric dams in the Teles Pires River basin, state of Mato Grosso, Brazil, will allow *C. fluminea* to become a significant problem. Here, we assess the presence and dispersal over six years of this species to new sites in the Teles Pires River. Our goal was to allow comparison, monitoring and management of this invasive species in response to the changes caused by building dams.

The Teles Pires River basin (Figure 1) is located between latitudes 08°57′ and 14°54′ S and longitudes 053°58′ and 057°02′ W, in the north-central portion of the state of Mato Grosso. The Teles Pires is a tributary of the Tapajós River, Amazon Basin. We sampled 10

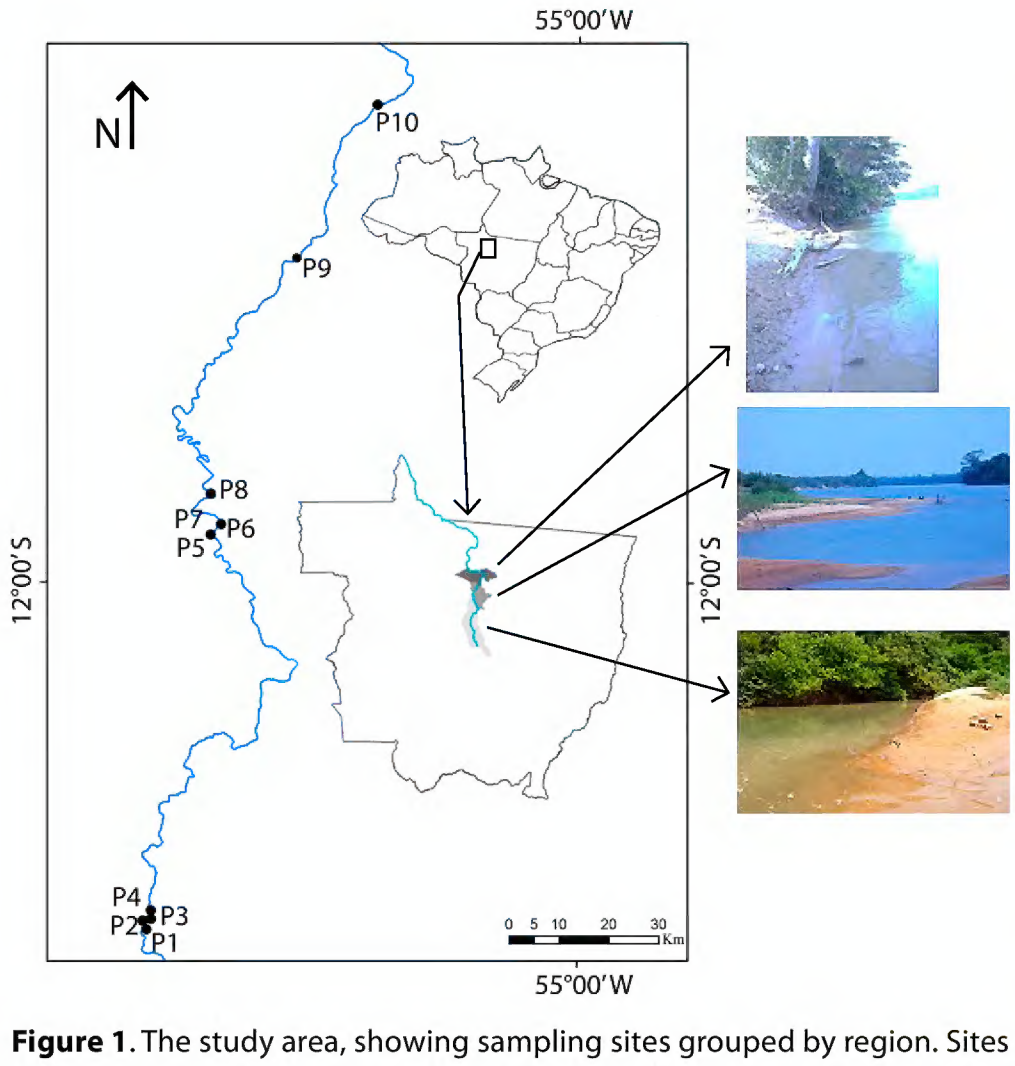

Figure 1. The study area, showing sampling sites grouped by region. Sites 1, 2, 3 and 4, region 1. Sites 5, 6, 7 and 8, region 2. Region 3, sites 9, and 10.

sites along the Teles Pires River in September 2006 and September 2012. We standardized the sampling effort by the number of hauls (50), distance (1 m) and sieve size (60 cm radius). After collection, specimens were transported to the laboratory where we measured the biometrics. We used a simple linear regression to assess the density of *C. fluminea* at 10 sites for both years. All specimens sampled were deposited in the Collection of Mollusks of the Federal University of Mato Grosso under the following records: CIAMT-MOL509, CIAMT-MOL 510, CIAMT-MOL 511, CIAMT-MOL 512, CIAMT-MOL 513, CIAMT-MOL 516, CIAMT-MOL 517, CIAMT-MOL 518 and CIAMT-MOL 519.

In 2006, *C. fluminea* was present in seven of the 10 sampled sites; 954 individuals were collected. The mean population density was 6.36 individuals/m² (range: 0.80–36.27 individuals/m²). In 2012, 3,733 individuals were collected at the same 10 sites, *C. fluminea* was still present in all sites. The mean density was 26.42 individuals/m² (range: from 0.35–217.13 individuals/m²) (Table 1).

Table 1. Population densities of *Corbicula fluminea* in the Teles Pires River, Mato Grosso, Brazil, on collection sites between 2006 and 2012.

		Densities	
Sites	**Coordinates**	**2006**	**2012**
01	12°37'37" S, 055°47'36"W	0.00	10.40
02	12°36'53" S, 055°47'44"W	0.80	0.78
03	12°36'34" S, 055°47'23"W	0.00	4.10
04	12°35'55" S, 055°47'17"W	1.34	24.98
05	11°54'50" S, 055°40'35"W	1.74	0.64
06	11°53'51" S, 055°39'29"W	13.54	2.83
07	11°53'41" S, 055°39'29"W	8.07	0.35
08	11°50'21" S, 055°40'30"W	36.27	217.13
09	11°24'36" S, 055°31'11"W	1.87	2.62
10	11°08'03" S, 055°21'58"W	0.00	0.35
Mean		**6.36**	**26.42**

Between 2006 and 2012 the total density of *C. fluminea* increased at six of our 10 sites. Compared to other regions of Brazil (Table 2), the population density in the Teles Pires River is relatively low. However, an increase of in the number of individuals and sites as well as densities within some sites for *C. fluminea* was confirmed. We recognize the possibility that this species is becoming a pest. In the South Region of Brazil, density studies reported that within a few years of colonization, the population of *C. fluminea* reached 5,000 individuals/m² (Mansur and Garces 1988).

We found that between 2006 and 2012 the total density of *C. fluminea* increased, and that among the 10 sites, six had higher densities. However, at three of our sites on the middle stretch of river, as well as one other upstream site, there was a small decrease in population densities at these sites. Although several factors, determined by differences in geography, can influence the density of *C. fluminea*, the most important factor is the time that introduction of the species occurred. Based on an analysis of biometric structure of the population and the dates of first records, Beasley et al. (2003) suggested that in the state of Pará *C. fluminea* was an introduced between 1997 and 1998. Callil and Mansur (2002) estimated the species' arrival in the Pantanal Matogrosense Cuiabá River between 1996 and 1997. These dates are close to our estimated year of introduction of *C. fluminea* to the Teles Pires River, between 1998 and 2001, based on the biometric analysis of shells collected in 2006 and following the shell growth patterns established by Cataldo and Boltovskoy (1998), Cataldo et al. (2001), and Callil and Mansur (2002). Despite of the similarities at the time of arrival, the population density may vary due to environmental conditions (Sousa 2008a); the portion of Teles Pires River that is part of the Amazon basin is an altogether different environment compared to the wetlands in the basins of Paraguay and La Plata rivers.

In 2006, the length of the smallest individual collected measured 2.50 mm and the largest 30.43 mm, with a mean value of 18.61 ± 7.02 mm. Specimens from 2012 varied in length from 4.11 to 32.35 mm, with a mean length of 26.07 ± 4.63 mm. Although 25 times denser, the population was similarly structured between 2006 and 2012 in the Region 1 with the most frequent length classes about 27.00 mm. Downstream in the Region 2, the population presented a highest frequency of individuals at the length class of 20.00 mm in 2006 and 30.00 mm in 2012 but 100 times denser. This suggests that *C. fluminea* is well established in both stretches of river, and probably, individuals are drifting downstream. The individuals belonging to the length classes around 5.00 and 7.50 mm occurred in practically

Table 2. Population densities of *Corbicula fluminea* elsewhere in Brazil and around the world.

Site	Densities (individuals/m²)	Literature
South Atlantic Rio Grande do Sul	5,000	Mansur and Garces (1988)
Paraguay River basin, state of Mato Grosso	192	Callil and Mansur (2002)
Tietê River basin, São Paulo	1,499	Suriane et al. (2007)
Sapucaí/Grande basin, state of São Paulo	1,282	Vianna and Avelar (2010)
Colombia	100	Aristizabal (2008)
Iberian Peninsula	521 and 1320	Sousa et al. (2008b)
Portugal	11142 ind/m²	Franco et al. (2011)
Lake Constance (Western Europe)	2037 ind/m²	Werner and Rothaupt 2008

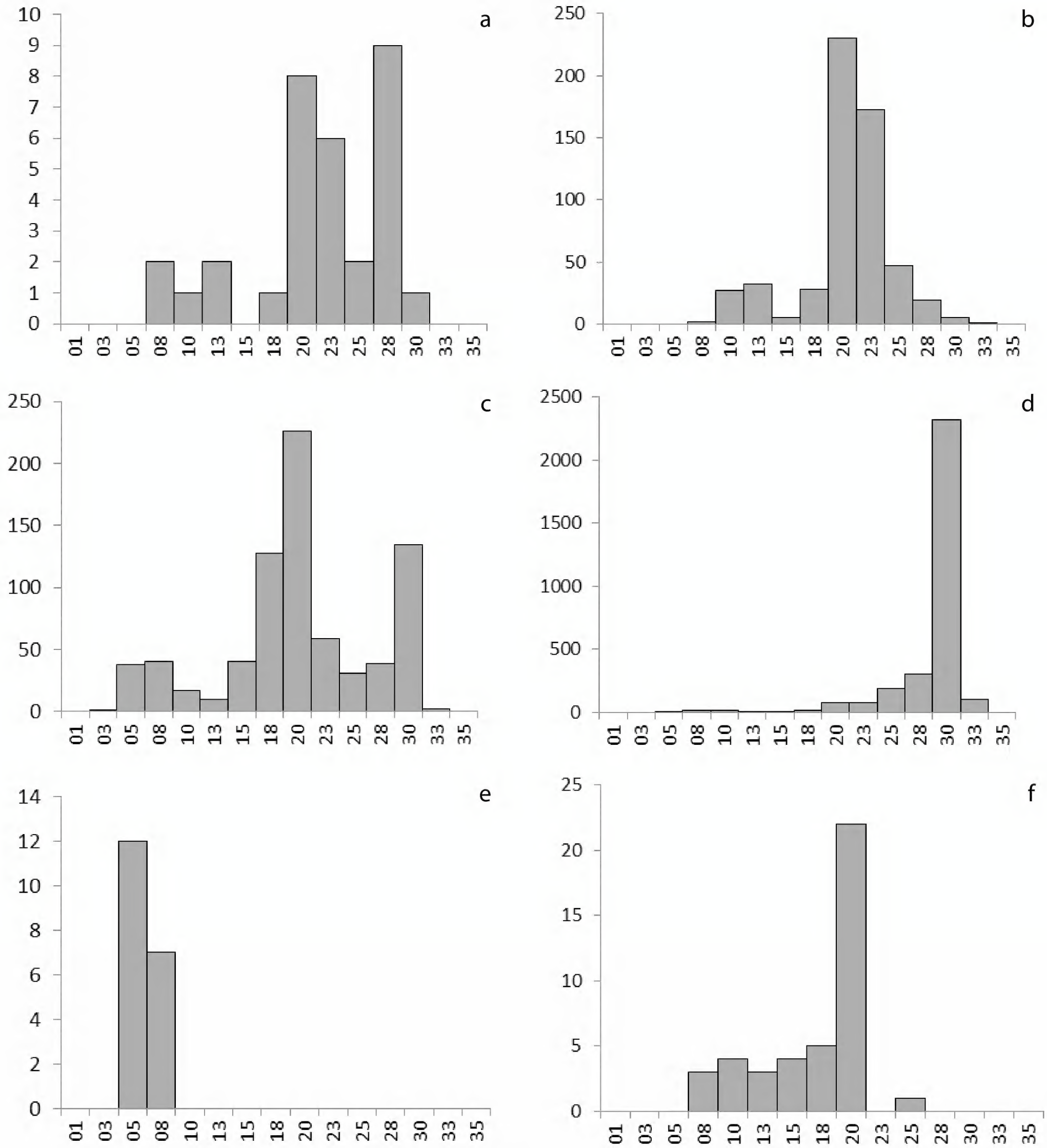

Figure 2. Distribution by length classes of *Corbicula fluminea* (Müller, 1774) by river stretch (Region 1 = a, b; Region 2 = c, d; Region 3 = e, f), collected in the Teles Pires River, Mato Grosso, Brazil. 2006 (a, c, e) and 2012 (b, d, f). X-axis = length classes, axis y = frequency of individuals.

all samples. However, in Region 3, despite showing an average increase in shell lengths, 5.0 to 20.0 mm, there was no increase in density (Figures 2a, 2c and 2e). The increase in mean size of individuals and the changes in the distribution of length frequency for the Teles Pires population is comparable to data of the population of *C. fluminea* from Argentina (Cataldo and Boltovskoy 1998) and suggests that the Teles Pires population is healthy and expanding.

The current situation in the Teles Pires River basin is worrying. The hydrological dynamics of the river will undergo changes with the building of hydroelectric dams and reservoirs. The replacement of lotic by lentic environments will drive changes in the structure of aquatic community and allow for the spread not only *C. fluminea*, but also other exotic species such as *Hydrilla verticillata* L.f. Royle and *Limnoperna fortunei* (Dunker, 1857), as are already happening in other reservoirs in the Neotropics (Michelan et al. 2014). The colonization of hydroelectric reservoirs by *C. fluminea* is expedited by the absence of water flow, which allows individuals to more easily settle on the bottom (Simone 2002). No found *C. fluminea* were found during the rainy season. This absence was also observed in the Negro River (Pimpão and Martins 2008); Cuiabá River (Massoli and Callil 2012) and in the Lake Constance (Werner and Rothaupt 2008). The rainwater increases the flow of the rivers and individuals can be carried with the surface sediments, or else, they can bury to protect themselves from strong current. Just as occurred in the Tiete river, (Rocha et al. 2011), damming on the Teles Pires River will provide a refuge for *C. fluminea*, free from the adverse effects of strong currents, contributing to increases of the population in this river.

Based on these results, monitoring of the *C. fluminea* population both during and after the construction of dams on the Teles Pires River should be considered.

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